

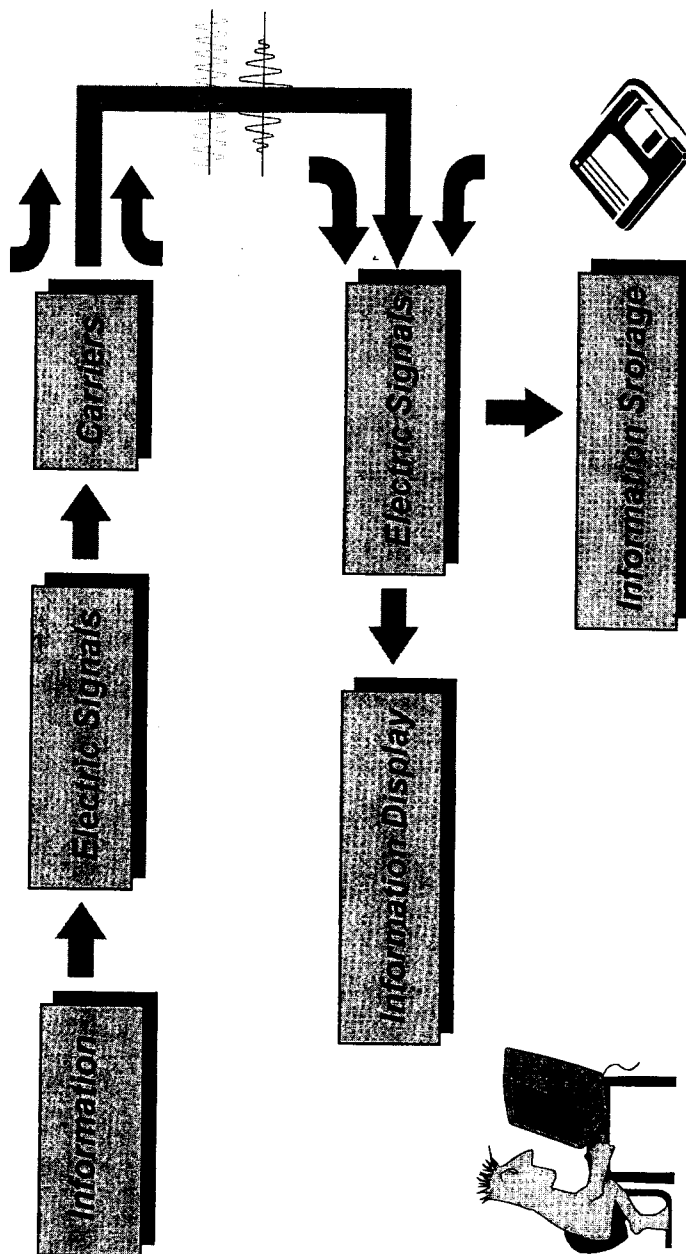
**Molecular Design of Organic Polymers for  
Optical Information/Communication  
Technology**

KIST

교 수 김 낙 중

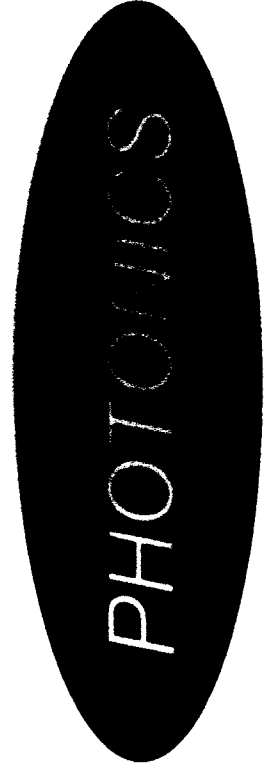
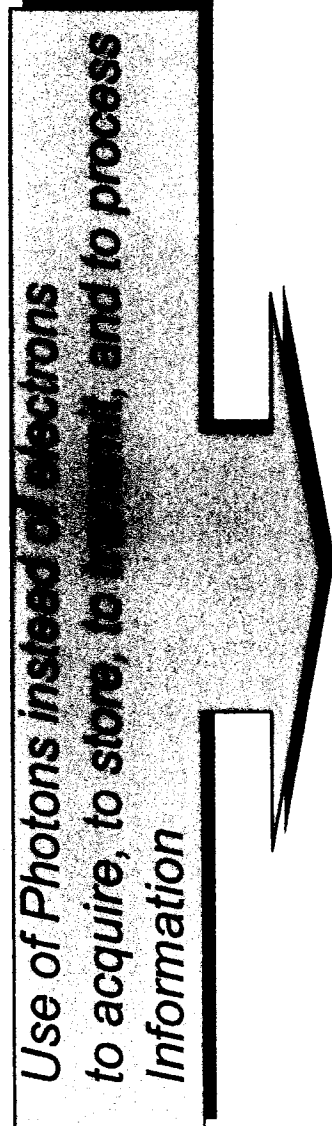
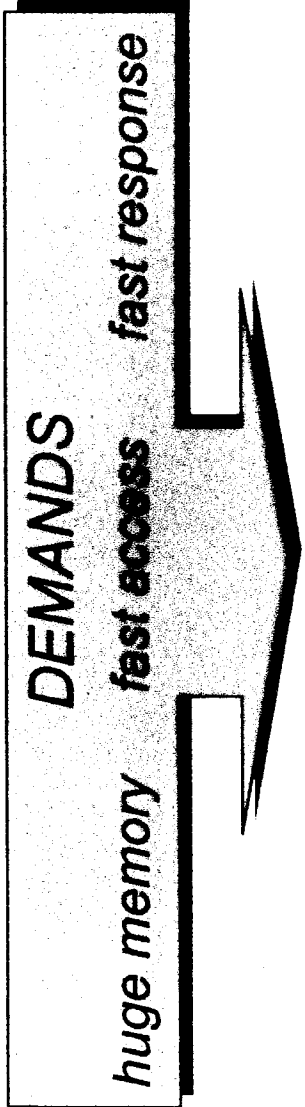
# *Information & Communication Technology*

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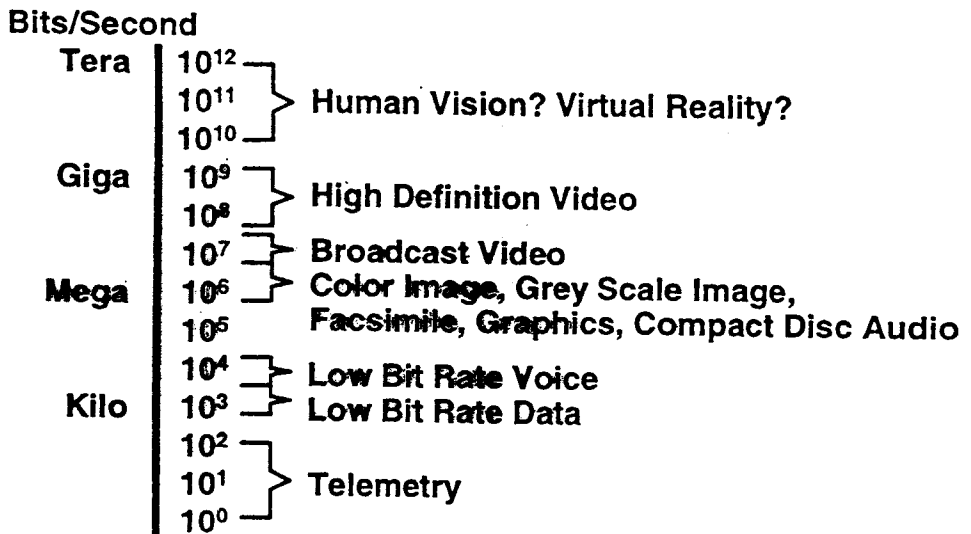


## 광산업용 유기 재료 및 소자

1. 광전송: 광섬유 및 광도파로 재료
  2. 광원: 유기 레이저 재료
  3. 광제어: 2차, 3차 비선형 광학 재료
  4. 광기록: 광이성화 재료, 광변색 재료, 광굴절 재료
  5. 광표시: 액정 디스플레이, 컬러 필터, 발광 재료
  6. 광전도: 프린터용 감광체 재료
  7. 기타: 투명폴라스틱 (광학렌즈), 광디스크 재료
- Photoresist용 재료**



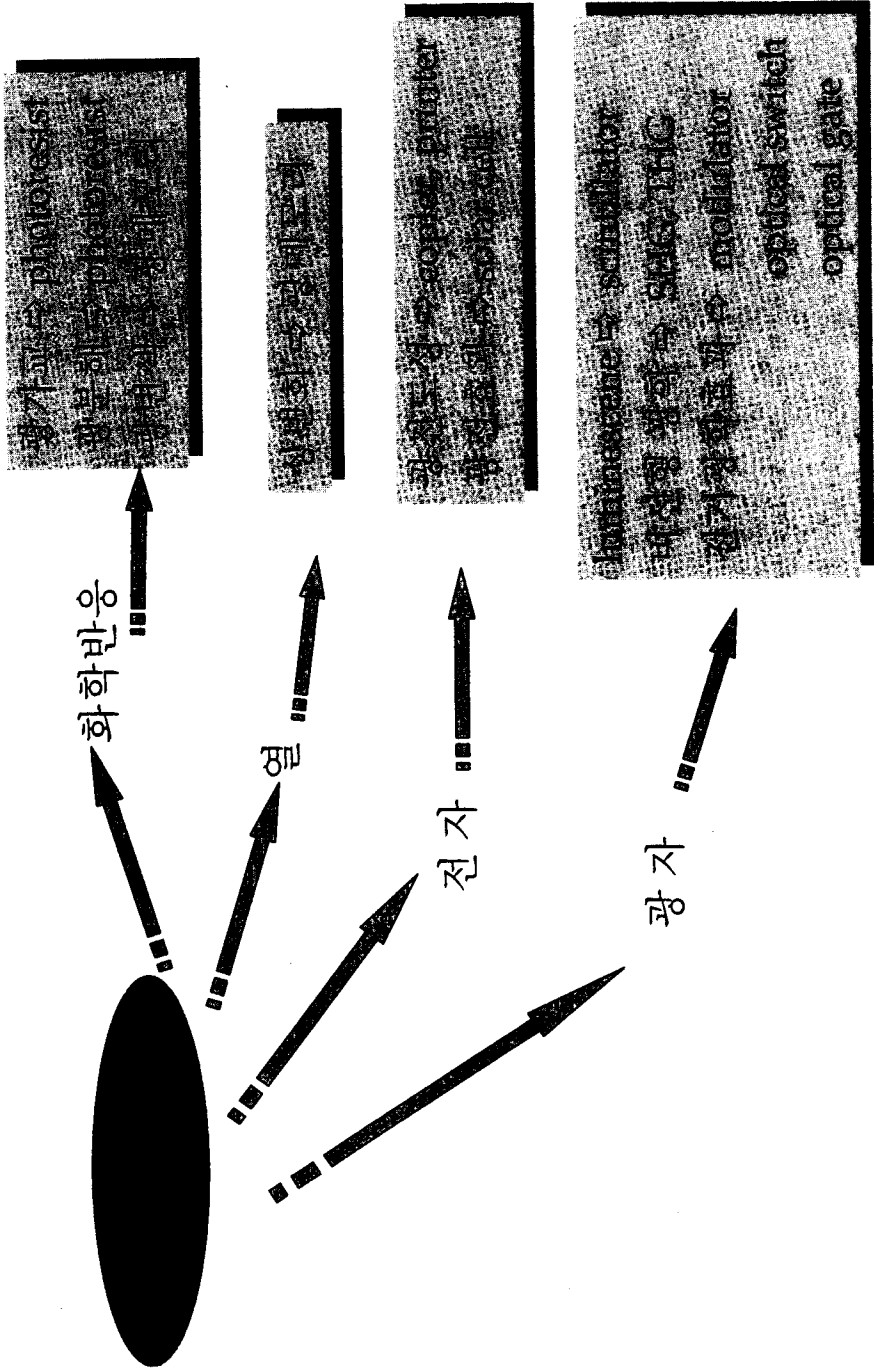
## Information Services Bit Rate Requirements:



## Characteristics of Photonics in comparison to Electronics

	Electronics	Photonics
Signal Carrier	electron	photon
Carrier Frequency	GHz	THz
Switching Time	ns and less	fs
Signal Propagation	wire, IC	fiber, Integrated optic
Signal Processing	conduction process , limited by carrier mobility	nonlinear optical process, limited by low nonlinearity
Parallel Processing	possible by increasing the number of elements in a circuit	possible by direct interaction of optical fields
Resistance to EMF noise and cross-talk	low without shielding	very good
Integration Scale	very high	needs improvement

# 유기물의 광기능과 응용

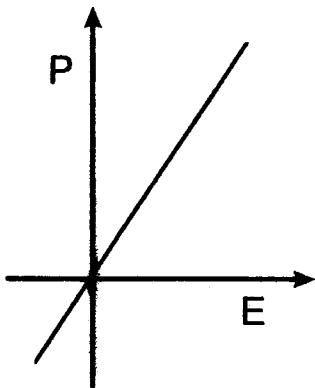


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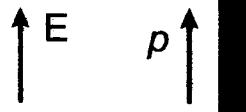
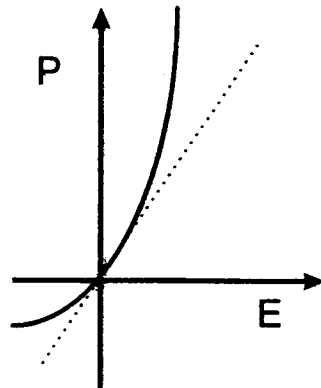
## Light Propagation Through an Optical Media

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### Isotropic Media



### Nonlinear Optical Media



Induced Dipole ( Molecular Level )

$$\rho_i(E) = \alpha_i E + \beta_i E^2 + \gamma_i E^3$$



## Polarization ( Macroscopic Level )

$$\begin{aligned} P &= \sum p_i \\ &= \chi^{(1)}E + \chi^{(2)}E \cdot E + \chi^{(3)}E \cdot E \cdot E \dots \\ &= \chi \cdot E \end{aligned}$$

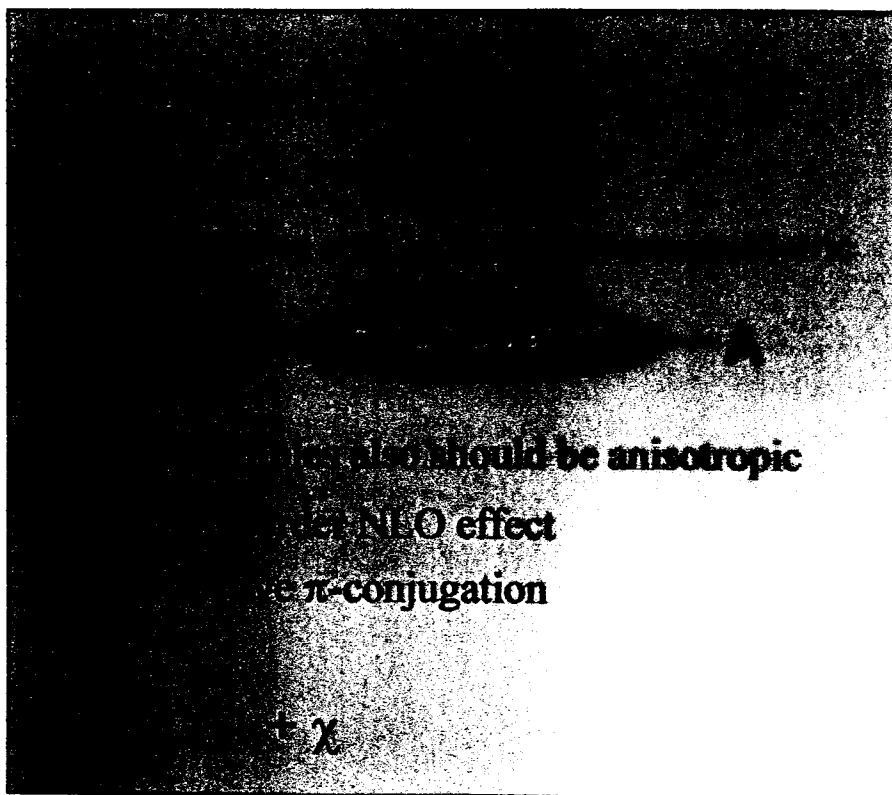
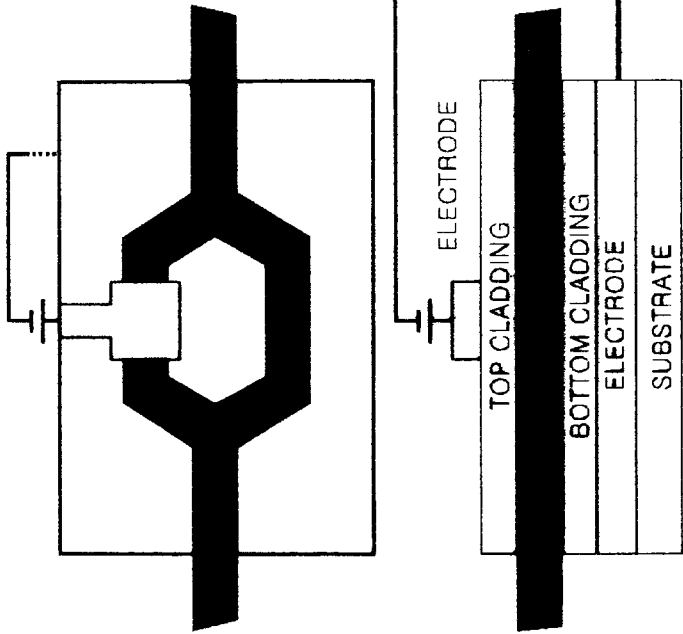


표 5. 비선형 광학 현상 및 응용

Susceptibility	Effects	Applications
<b>Linear</b>		
$\chi^{(1)}(-\omega; \omega)$	Refractive Index	Optical fiber, Waveguide
<b>Second-Order Nonlinear</b>		
$\chi^{(2)}(-2\omega; \omega, \omega)$	Second Harmonic Generation	Frequency Doubler
$\chi^{(2)}(-\omega_3; \omega_1, \omega_2)$	Frequency Conversion	Sum and Difference Frequency Generation
$\chi^{(2)}(-0; \omega, -\omega)$	Optical Rectification	dc Generation
$\chi^{(2)}(-\omega_s, -\omega_i; \omega_p)$	Parametric Oscillation	Laser Oscillation
$\chi^{(2)}(-\omega_s, -\omega_i; \omega_p)$	Parametric Amplification	Amplifier
$\chi^{(2)}(-\omega; \omega, 0)$	Pockels Effect	EO Modulator
<b>Third-Order Nonlinear</b>		
$\chi^{(3)}(-3\omega; \omega, \omega, \omega)$	Third-Harmonic Generation	Frequency Tripler
$\chi^{(3)}(-\omega; \omega, -\omega, \omega)$	Optical Kerr Effect	Optical Bistability (Memory, Logic gate)
$\chi^{(3)}(-2\omega; \omega, \omega, 0)$	EFISH	Measurement of $\beta$
$\chi^{(3)}(-\omega; \omega, 0, 0)$	Kerr Effect	Optical Shutter
$\chi^{(3)}(-\omega_4; \omega_1, \omega_2, \omega_3)$	Four-Wave Mixing	Frequency Conversion Phase Conjugation

# Mach-Zehnder Type Modulator

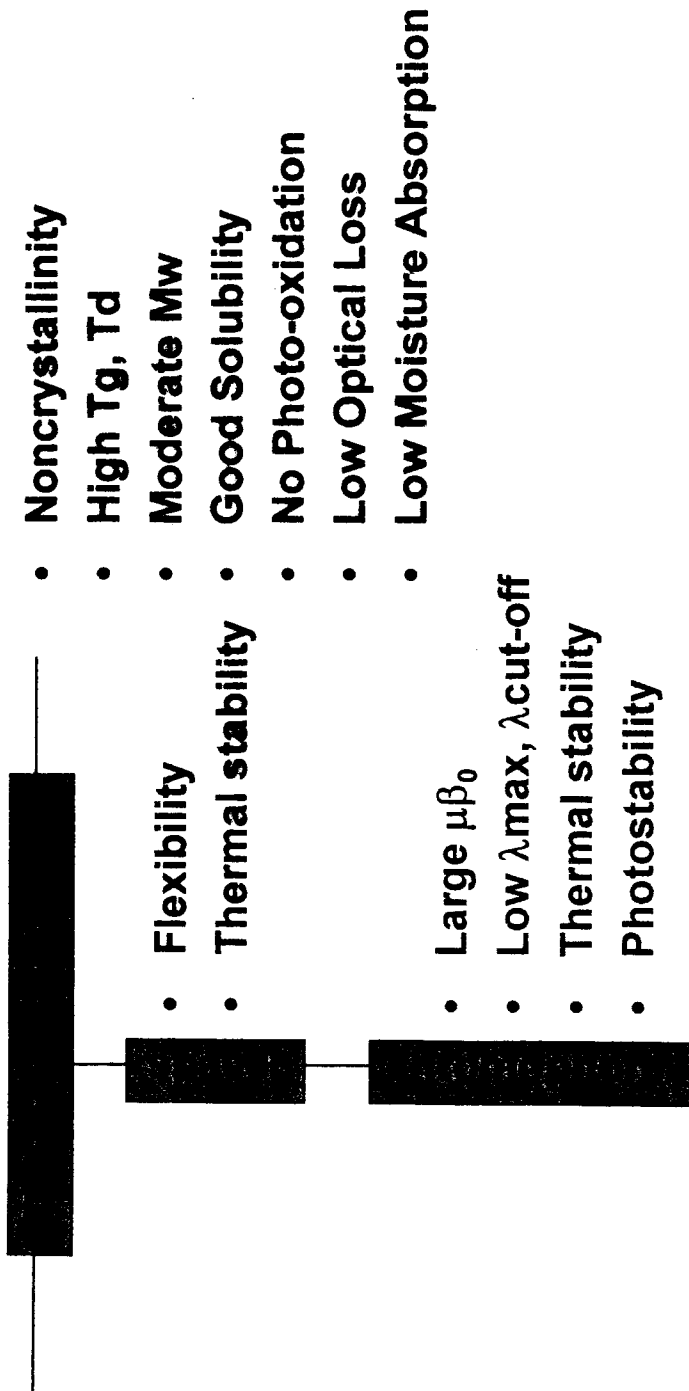


$$V\pi = (\lambda / n^3 r_{33}) (t / L\Gamma)$$

where

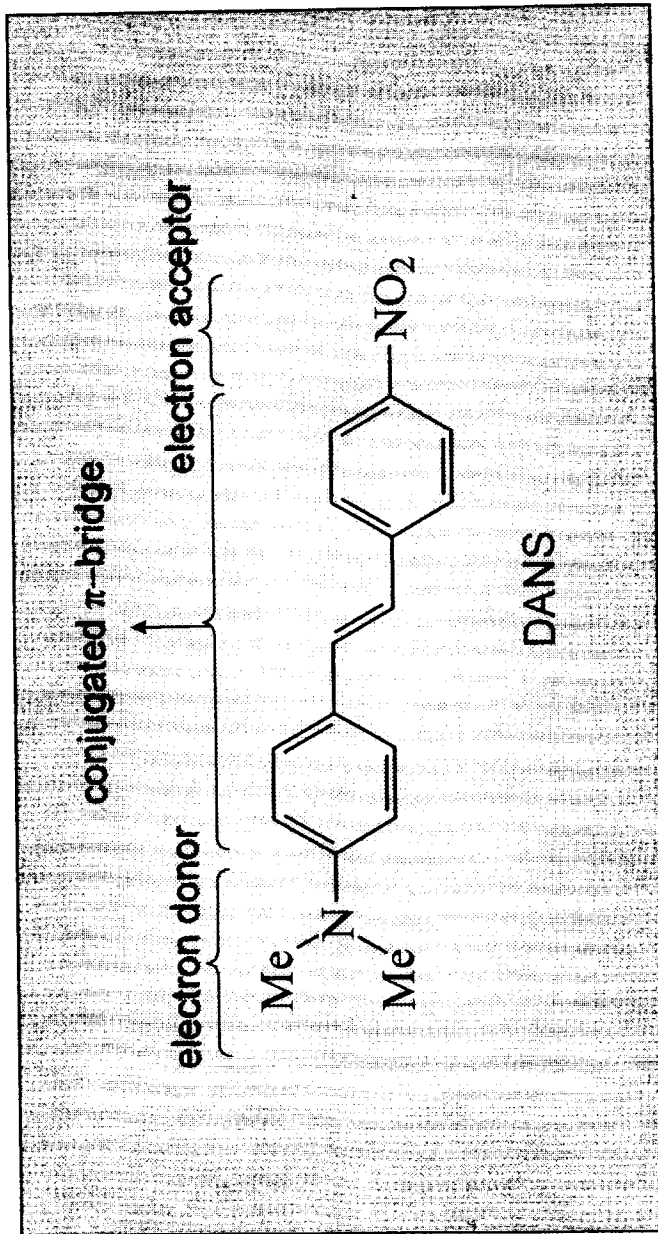
- $\lambda$ : wavelength of light source
- $n$ : refractive index
- $r_{33}$ : electr-optic coefficient
- $t$ : distance between electrodes
- $L$ : electrode length
- $\Gamma$ : overlap factor

## *Requirements of Electro-optic Materials Units*



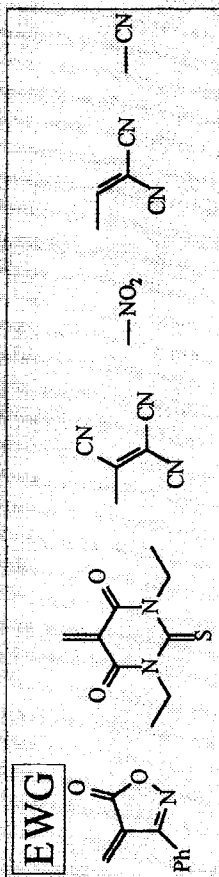
# Push-Pull Chromophores for Quadratic Nonlinear Optics

## Push-Pull Systems







# NLO chromophore design to increase first-order hyperpolarizability

## 1. Introduction of strong electron acceptor



## 2. $\pi$ -Conjugation type and length

## 3. Charge transfer energy bands : $\beta \propto (\mu_{ee} - \mu_{gg}) (\mu_{ge}^2 / E_{ge}^2)$

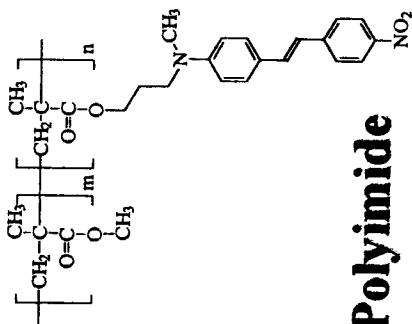
			
ER (kcal/mol) 15.8	21.2	28.7	36.0

# Organic Materials System for 2nd-order NLO

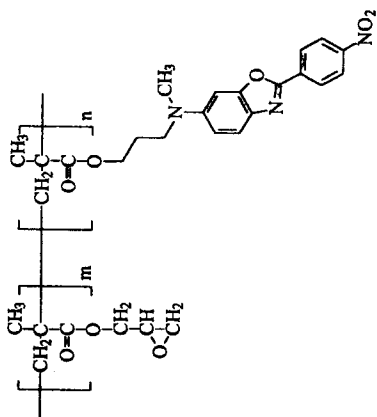
1. Bulk Organic Crystals
2. Liquid Crystal Polymers
3. Langmuir-Blodgett Film
4. Poled Polymer
  - i) Guest-Host System
  - ii) Side-Chain Polymer
  - iii) Main Chain Polymer
  - iv) Crosslinked Polymer
  - v) Sol-Gel System
5. Nonpoled System
6. Self Assembly

# 다양한 고분자 매트릭스 Survey

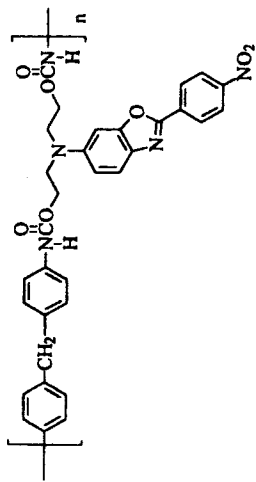
## MMA copolymer



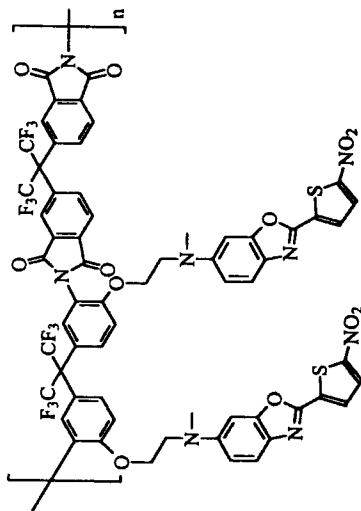
## GMA copolymer



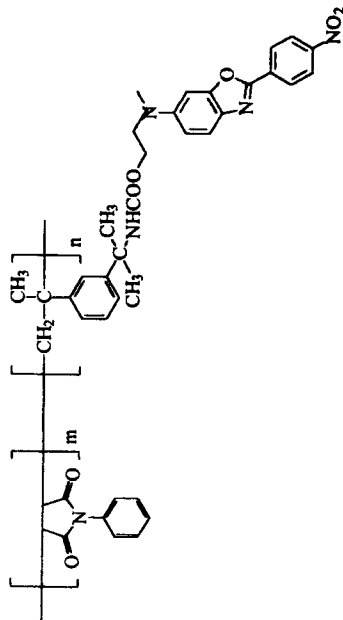
## Polyurethane



## Polyimide



## Maleimide copolymer



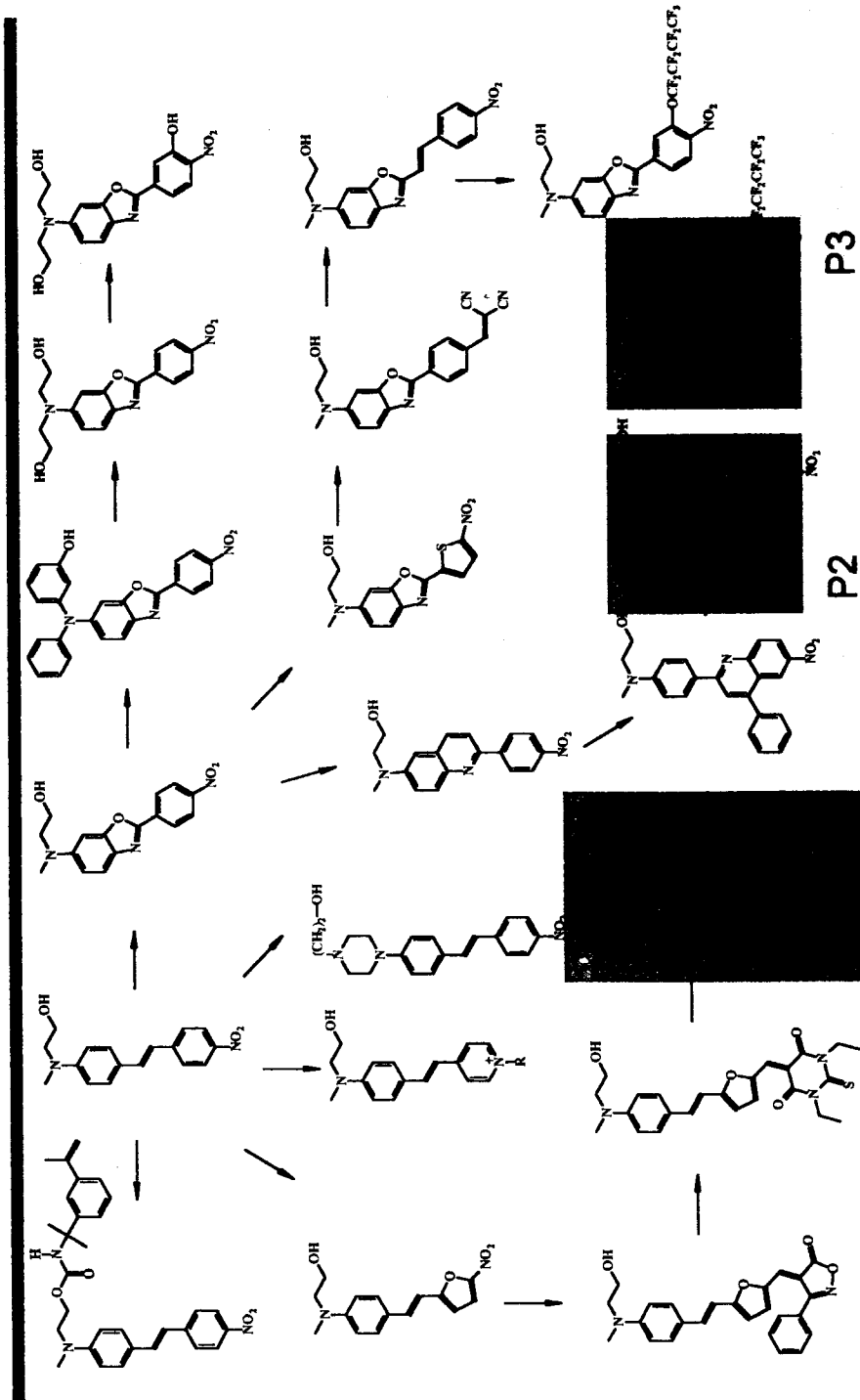
한국과학기술연구원

정보 재료 소자 연구 센터

CIKIS(2000)최종보고



# 헤테로환계 NLO 발색단 개발



한국과학기술연구원

정보재료소자연구센터

c:KIs(2000)최종보고

# Electronics and Photonics Age

